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ABSTRACT

This unit teaching guide is designed to help teachers explain the principles of fertilizer and lime use. The first of four major sections is a teaching outline keyed to transparency masters and student handouts. Thirteen major areas are covered in the teaching outline: (1) plant needs; (2) uses of fertilizer; (3) nutrients for plant growth; (4) planning the fertilizer program based on the soil test; (5) classification of fertilizers; (6) some types of nitrogen, phosphorus, and potassium fertilizers; (7) reading the fertiizer label; (8) soil pH and the use of limestone; (9) rate of application; (10) time of application; (11) application methods; (12) consideration for fertilizer selection and application; and (13) student application exercises. Sections 2 and 3 contain student handouts and a list of teacher and student references. The final section contains overhead transparency masters that complement the unit. (LRA)

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AGDEX 540

FERTILIZER AND LIME

WHY THEY ARE USED

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FERTILIZER AND LIME: Why they are used

by Judith Strand McCaslin

This unit was written to help teachers explain the principles of fertilizer and lime use. Students should possess an understanding of soils - their structure and texture - and plant-soil relationships.

The unit consists of:

- a teaching outline with aids
- overhead transparency masters (TMs)
- handouts
- listing of teacher and student references

Transparency masters and handouts are keyed to the teacher outline.

OBJECTIVES

At the completion of this unit the student will be able to:

1. List the 16 elements required for healthy plant growth.
2. Describe the deficiency symptoms of nitrogen, phosphorus, and potassium.
3. Name a soil amendment used to raise soil pH and one used to lower soil pH.
4. Calculate the amount of a given fertilizer to apply to an acre to obtain a specified amount of nitrogen.
5. Given two bags of fertilizer - their analysis and cost - calculate which one is the best buy.
6. Calculate the amount of nitrogen, phosphorus, and potassium when given a container of complete fertilizer.
7. Describe two methods to determine if soil nutrition is adequate for optimum plant growth.
8. Use an element deficiency key to state the possible nutrient deficiences of an unhealthy plant by a visual test.
9. Name three sources of recommendations to properly adjust the soil for mineral nutrition and/or pH.

LIST OF TRANSPARENCY MASTERS

Master #	Description
TM-1	Five things that affect plant growth
TM-2a	Decaying plant material returns elements to the soil
TM-2b	Removal of plant litter breaks the cycle (overlay)
TM-3	Higher yielding varieties have higher nutrient demands
TM-4	To add elements, add fertilizer
TM-5	Essential elements
TM-6	Deficiency and symptoms
TM-7	Soil testing
TM-8	Fertilizer program
TM-9a	Too much fertilizer
TM-9b	Too little fertilizer (overlay)
TM-10	Planning a fertilizer program
TM-11	What fertilizer investment gives the most profit?
TM-12	What fertilizer rate gives the most profit?
TM-13	Organic fertilizers
TM-14	Nutrient content of fresh manure
TM-15	Amount of nutrients available for plant use for one year
TM-16	Inorganic fertilizers
TM-17	Slow-release fertilizers
TM-18	Complete fertilizer
TM-19	Nitrogen (N)
TM-20	Phosphorus (P)
TM-21	Potassium (K)
TM-22	Reading the fertilizer label
TM-23	Which bag of fertilizer has more phosphorus in it?
TM-24	Which brand of fertilizer is the best deal?
TM-25	How much ammonium sulfate must be applied per acre?
TM-26	pH scale
TM-27	Availability of elements
TM-28	Recommended soil pH for some field crops
TM-29	Recommended soil pH for some fruit and nut crops
TM-30	Recommended soil pH for some vegetable and fruit crops
TM-31	Limestone
TM-32	How much fertilizer to apply
TM-33	Fertilizer application rate
TM-34	Time of application
TM-35	Ways to apply dry fertilizer
TM-36	Ways to apply liquid fertilizer
TM-37	Selecting a fertilizer and application method
TM-38	Problem situation
TM-39	Problem situation
TM-40	Problem situation

TEACHING OUTLINE

I. Plant Needs

TM-1

A. For normal, healthy growth plants require a proper balance of water, carbon dioxide from the air, light, temperature and chemical elements.

B. Sun, temperature and carbon dioxide are difficult to adjust on a large-scale basis. Water can be supplemented by irrigation. One of the easiest factors to change is the mineral content of the soil by the addition of fertilizer and lime.

C. There are 16 chemical elements required for healthy plant growth. If one or more of the 16 are deficient or absent plant growth is affected.

D. Fertilizers and lime are used to supplement the natural mineral content of the soil, to help insure that plant requirements are met.

II. Use of Fertilizers

A. Plant growth depletes the soil of nutrients.

1. Plants do not destroy elements removed from the soil. Elements become, in effect, part of the plant structure.

TM-2a

2. If plant litter is not removed, minerals are returned to the soil as the plant decays.

TM-2b (overlay)

3. This cycle is broken when entire plants are harvested and removed leaving little or no plant litter to decay and return nutrients.

   a. Natural weathering and leaching of elements by water also depletes the soil.

4. In early times, people learned to improve crop production by adding animal manures (feces, sewage, blood), vegetable refuse (burnt prunings, cuttings), and interplanting with legumes (a plant family with nodules containing nitrogen fixing bacteria on the roots).

5. In the 20th century, scientists identified the elements required by plants. Products could be manufactured that delivered the needed elements.

6. Demand for more food from less available land area has resulted in:

   a. *intensive cropping* which depletes the soil of its nutrients

   b. development of plant varieties with *high yield potential* (increasing crop yield demands more nutrients)

TM-3

   c. need to apply *fertilizer* to the soil to replenish elements and to provide enough nutrients for new high yield varieties.

TM-4

7. Sterile artificial mixes require the addition of elements when producing ornamental crops.

B. Successful fertilizer application requires knowledge of the nutrients necessary for healthy plant growth.

III. Nutrients for Plant Growth

TM-5

A. There are 16 essential elements for plant growth and development: C HOPKNS CaFe Mg B Mn CuZn Mo Cl. (Remembered as "See Hopkin's cafe managed by mine cousins Moe and Clyde.")

1. Three are obtained from air* and water: carbon, hydrogen, and oxygen. (*Although not a concern to the farmer, the greenhouse crop producer must consider plant needs for fresh air.)

2. The remaining 13 are obtained from soil.

a. Six are considered macronutrients because they are required in relatively large amounts:

nitrogen	N	calcium	Ca
phosphrous	P	magnesium	Mg
potassium	K	sulfur	S

b. Seven are considered micronutrients because they are required in smaller amounts by the plant. These are less likely to be deficient in the plant. They are just as vital as macronutrients. (Growers of crops in soilless media must consider these elements, especially iron.)

iron	Fe	molybedenum	Mo
copper	Cu	boron	B
zinc	Zn	chlorine	Cl
manganese	Mn		

(1) Micronutrients are often called "trace elements" and are available in two forms:

fritted trace elements: elements commonly infused in slowly dissolving soft glass, which releases the elements slowly, they are usually incorporated in the soil once a year

soluable trace elements: elements applied in liquid form to soil or foliage; elements are rapidly available to the plant

Handout 1

B. Each element performs important specific functions in the plant. But plants vary in how much of each element they need.

Handout 2
TM-6

C. Each element has specific symptoms related to its deficiency.

1. Determining deficient elements by observing an unhealthy plant is difficult since deficiency symptoms are similar for several elements or can be caused by other factors (such as insects, diseases, or environmental conditions).

2. Tissue tests can be taken during the growing season to verify symptoms; however, identification of soil deficiencies before crops are planted will help prevent a reduced crop yield.

3. A soil test should be made to determine nutrient availability.

IV. Planning the Fertilizer Program Based on the Soil Test

A. Test the soil using a soil test kit or submit a soil sample to a reputable soil testing laboratory (such as the Cornell Soil Test Laboratory, Department of Agronomy, 8th Floor, Bradfield Hall, Cornell University, Ithaca, NY 14853)

1. Prepare the soil sample carefully - make sure it is representative of the field or soil mix being used.

2. The laboratory will perform the test and determine the amount and kind of fertilizer required for maximum economic return from the crop.

TM-8

B. Plan a fertilizer program by comparing soil test results to crop requirements.

1. Too much fertilizer

a. is *wasteful*: wastes money, runoff of excess fertilizer is harmful to the environment

b. can cause *toxicity*: injures germinating seed or seedling (known as "salt burn") and reduces germination or early seedling growth

c. can cause *deficiency*: excess amount of one element can cause the deficiency of another

d. PROFIT IS REDUCED

TM-9b
(overlay)

2. Too little fertilizer

a. reduced yield

b. crop quality may be affected so it is less marketable (e.g. fruit not firm, stems cracked, foliage yellow, few flowers)

c. PROFIT IS REDUCED

3. Manager/producer wants maximum economic returns (greatest profit) from crop

TM-10

a. consider *effect* of fertilizer application on crop yields

b. consider *cost* of fertilizer

c. consider *dollar return* of increased yield or improved appearance

TM-11

d. compare *cost to income*

e. apply *amount* that gives you the most profit ($25-30 per acre in TM-11)

TM-12

f. maximum profit per acre is reached by adding fertilizer until returns equal the cost of the last increment

V. Classification of Fertilizers

TMs-13, 14, 15

A. Organic Fertilizers

1. Derived directly from animal and plant sources, e.g. manure, bone meal, compost, crop residues

2. Usually contain <u>many</u> plant nutrients, but in <u>low</u> concentrations

3. All nutrients must be converted to inorganic forms to be absorbed by the plant

4. Advantages of organic fertilizers

   a. composed of more than one nutrient (element)

   b. releases nutrients slowly - less likely to be leached from the soil before used by the plant

   c. improves soil tilth and physical condition

   d. increases water retention (especially good for sandy soils)

   e. decreases need for manufactured fertilizers

   f. often costs less

5. Disadvantages of organic fertilizers

   a. usually low in nitrogen

   b. salts not needed by plant may accumulate in the soil

   c. generally carries weed seeds unless processed

TM-16

B. Inorganic Fertilizers

1. Not derived directly from an animal or plant source; usually manufactured and are called commercial fertilizers

2. Usually provide three macronutrients - nitrogen, phosphorus, and potassium - in concentrated form

3. Advantages of inorganic fertilizers

   a. concentrated solutions, apply only small amounts

   b. easy to handle

   c. adds only needed elements to soil

4. Disadvantages of inorganic fertilizers

   a. must be accurate in application or excess amounts can be easily applied - too much of an element available at once is wasteful and may burn the plant

TM-17

C. Slow-release fertilizers

1. Usually refers to commercially-prepared nitrogen fertilizers

2. Granules are treated with coated material so only a small amount of the fertilizer is released with each application of water

3. Economically suitable for pot plant culture or for home-owner use in landscaping

4. Examples: Osmocote and MagAmp

TM-18

D. Complete fertilizers

1. Contain all three primary macronutrients: nitrogen, phosphorus, and potassium

2. Either organic or inorganic

3. Disadvantages

   a. more expensive than buying single elements (called 'separates')

   b. can build up excess salts in soil

VI. Some Types of Nitrogen, Phosphorus, and Potassium Fertilizers

TM-19

A. Nitrogen Fertilizers

1. Application: Fertilizer nitrogen dissolves readily in water and is quickly leached from the soil. Thus, apply it in small amounts several times during the growing season.

2. Inorganic sources with approximate nitrogen content

   a. ammonium nitrate, 33% N

   b. ammonium sulfate, 21% N

   c. potassium nitrate, 18% N

   d. anhydrous ammonia, 82% N

3. Organic sources with approximate nitrogen content

   a. urea (synthetic), 42% N

   b. blood meal, 13% N

   c. cottonseed meal, 6-7% N

   d. fish meal, 10% N

   e. manure, 1-4% N

   f. uramite (slow release), 38% N

TM-20

B. Phosphorus Fertilizers

1. Application: Phosphorus is not very mobile in the soil; therefore, it must be placed in the soil at the root zone for uptake by the plant. It is best to apply phosphorus fertilizers <u>before</u> planting.

2. Phosphorus is available as phosphate, P_2O_5 ($0.44 \times \%P_2O_5 = \%P$).

3. Types with approximate phosphate (P_2O_5) content

   a. single superphosphate, 18-20% P_2O_5

   b. triple superphosphate, 43-48% P_2O_5

   c. bone meal, 23% P_2O_5

   d. ammonium phosphate, 20% P_2O_5

   e. monoammonium phosphate, 45-48% P_2O_5

   f. diammonium phosphate, 42-46% P_2O_5

TM-21

C. Potassium Fertilizers

1. Application: Potassium ions (K^+) are held in clay soils (clay particles have a negative charge), but are readily leached in sandy soils. Increased application is necessary in sandy soils.

2. Potassium is available as potash, K_2O (0.83 x $\%K_2O$ = $\%K$).

3. Types with approximate potash (K_2O) content

   a. potassium sulfate, 52% K_2O (soluble)

   b. potassium chloride, 60% K_2O (soluble)

   c. potassium nitrate, 44% K_2O (soluble)

   d. potassium glass, 38% K_2O (slowly soluble)

   e. MagAmp with K, 7% K_2O (slowly soluble)

TMs 22-25

VII. Reading the Fertilizer Label

A. By law, commercial fertilizers must display on the bag the percent by weight of nitrogen (N), phosphorus (expressed as P_2O_5), and potassium (expressed as K_2O), in that order. All three elements do not have to be present. Percentages will be found listed as:

1. Guaranteed Analysis - usually fine print

2. Three large numbers on the front of the package, such as 10-8-6, that represent in order %N, $\%P_2O_5$, % K_2O. Thus, 10-8-6 means that the fertilizer is 10%N, 8% P_2O_5, and 6% K_2O.

B. The label may also state:

1. Suggested rates of application

2. Suggested method of application

3. Suggested crops for which the fertilizer analysis is best suited, e.g. Rose Food, Houseplant Food, Citrus Food

VIII. Soil pH and the Use of Limestone

A. In addition to the soil mineral content, plant growth is affected by the soil pH.

TM-26

B. pH is the measure of how acid (or how basic) a medium (such as soil) is.

1. pH ranges from 1 to 14, with 1 being most acid, 14 most basic, and 7 neutral.

TM-27

2. pH affects the availability of elements to the plants.

3. Soil pH can be determined with an inexpensive pH test kit or laboratory test at the time soil element content is determined.

TMs-28,29,30
Handout 3

C. There are specific recommended soil pH levels for each crop (plant). For healthy growth and high yield, maintain the desirable pH level with soil amendments.

1. To lower pH (make more acid), apply gypsum ($CaSO_4$), sulfur or lime sulfur (CaS).

TM-31

2. To raise pH (make more basic), apply limestone ($CaCO_3$), dolomite ($CaCO_3$ and $MgCO_3$), or hydrated lime ($Ca(OH_2)$). Use of dolomitic limestone is recommended because it supplies magnesium, as well as calcium.

3. New York soils tend to be in the pH range of 5.4 to 7.0, so application of limestone is common.

IX. Rate of Application

TM-32

A. Factors Affecting Rate

1. Soil type (clay holds more elements for plant use; sandy soil allows leaching more readily)

2. Weather (more rain -- more leaching)

3. Season (longer season -- more growth -- greater needs)

4. Crop

TM-33

B. Sources of Rate Recommendations

1. Fertilizer label

2. Local County Cooperative Extension Office or agent

3. Publications, including Cornell Recommendations

TM-34

X. Time of Application

A. *Inorganic fertilizers:* just before and during the plant growing season

B. *Organic fertilizers:* work into the soil before planting

C. *Limestone:* work into soil before planting

XI. Application Methods

TM-35

A. Dry/granular Fertilizer Application

1. *Broadcast* by hand or with spreader (e.g. ammonia nitrogen): apply uniformly on surface before planting: sometimes disc in

2. *Band (or drill)*: apply in bands to one or both sides of the seed or plant or directly beneath the seed, usually at planting

3. *Sidedress*: after crop has emerged, fertilizer is placed on the soil surface to the side of the crop

4. *Incorporate* into soil (P, K) by hand or with drill

   a. ornamentals: dig trench at drip line of trees or make auger holes near trees

5. *Dissolve* granules in water and apply when irrigated

TM-36

B. Liquid Fertilizer Application

1. *Mix* in irrigation water

2. *Spray* on foliage surface (N, Fe, Zn, B, Mn)

3. *Inject* into soil in solution under pressure (anhydrous ammonia and nitrogen solutions)

4. *Trunk injection* of micronutrients (discouraged as wounds can lead to decay)

C. Limestone

1. *Apply* to surface: broadcast, band

2. *Disc* one-half of application into the soil to at least the seed depth. Apply one-half of application to surface

TM-37 XII. Considerations for Selection of Fertilizer and Application Method

A. Crop species
B. Soil type and analysis
C. Elements to be applied
D. Equipment available
E. Nature and slope of soil surface
F. Season
G. Weather
H. Other plants in the area (landscape plantings especially)
I. Commercial agencies available on contract

TMs- 38,39,40 XIII. Student Application Exercises

SUMMARY OF PLANT NUTRITION

Nutrient	Function in Plant	Deficiency Symptoms
N	Promotes rapid vegetative growth and gives plants a healthy green color	Stunted growth, light green leaves, burning of tips and margins of leaves starting at bottom of plant, lower leaves turn yellow and die, delayed maturity
P	Stimulates early growth and root formation, hastens maturity, promotes seed production, makes plants hardy	Purplish leaves, stems, and branches; reduced yields of seeds and fruits, stunted growth
K	Improves plant's ability to resist disease and cold, aids in the production of carbohydrates	Slow growth-reduced yields; mottled, spotted, or curled older leaves; browning on leaf edges; weak stalks and root system; shriveled seed or fruit
Ca	Aids in the movement of carbohydrates in plants, essential to healthy cell walls and root structure	Deformed younger leaves, reduced root growth, blossoms shed prematurely; under severe deficiency terminal bud dies, some plants turn black, dead spots in midrib of some plants
Mg	Ingredient of chlorophyll, aids in the movement of starch within a plant, essential for the formation of oils and fats	Yellow leaves, especially yellow between veins of older leaves, leaves may droop, leaves abnormally thin, tissue may dry and die
S	Aids in the formation of oils. (deficiency is unlikely)	Similar to N deficiency: reduced yields, older leaves yellow, stems and roots small
B	Aids flowering, pollen germination, fruiting (amount required is small, soil rarely deficient)	Terminal buds die repeatedly - branches form rosettes, leaves become thickened, curled, brittle
Fe	Essential for formation of chlorophyll and release of energy from carbohydrates	Yellowing of leaves (younger leaves first), veins remain green, affected leaves may curl (Grasses develop alternate rows of yellow and green stripes in leaves.)
Cu	Promotes formation of vitamin A, excess is very toxic	Bleached appearance of leaves, die-back of new growth in citrus

Mn	Essential for formation of chlorophyll	Light green leaves with darker green veins, leaves later become white and shed
Zn	Aids in formation of chlorophyll, seed production in legumes	"Little leaf" in citrus, chlorotic leaves with green veins, abnormal roots, rosetted leaves, reduced fruit formation, die-back of one-year old twigs
Mo	Aids plant in using nitrogen	Plants stunted and yellow in color (as nitrogen deficiency also may occur), rolled or cupped leaves, yellow spots on leaves
Cl	Stimulates manufacture of carbohydrates and chlorophyll, increases water-holding capacity of plant tissue	There is generally no deficiency of chlorine in soils.

Handout 2

KEY TO HELP IDENTIFY NUTRIENT DEFICIENCIES

I. Effects generally seen on whole plant or localized in older, lower leaves. (If not see II.)

A. Effects usually general on whole plant, often manifested by yellowing and dying of older leaves.

1. Foliage light green. Growth stunted, stalks slender, and a few new breaks. Leaves small, lower ones lighter yellow than upper ones. Yellowing followed by a drying to a light brown color, usually little dropping.

Deficient nitrogen (N)

2. Foliage dark green. Retarded growth. Lower leaves sometimes yellow between veins but more often purplish, especially on petiol.. Leaves dropping early.

Deficient phosphorus (P)

B. Effects usually local on older, lower, leaves.

1. Lower leaves mottled, usually with necrotic areas near tip and margins. Yellowing beginning at margin and continuing toward center. Margins later becoming brown, curving down, and older leaves dropping.

Deficient potassium (K)

2. Lower leaves chlorotic and usually necrotic in late stages. Chlorosis between the veins, veins normal green. Leaf margins curling upward, downward, or developing a puckering effect. Necrosis developing between the veins very suddenly, usually within 24 hours.

Deficient magnesium (Mg)

II. Effects seen locally on new leaves.

A. Terminal bud remains alive.

1. Leaves cholortic between the veins; veins remain green.

a. Necrotic spots usually absent. In extreme cases necrosis of margins and leaf tip, sometimes extending inward, developing large areas. Larger veins only remaining green.

Deficient iron (Fe)

Note: certain cultural factors, such as high pH, overwatering, low temperature, and nematodes on roots, may cause identical symptoms. But symptoms may still be from an iron deficiency in the plant due to a lack of iron caused by these factors.

b. Necrotic spots usually present and scattered over leaf surface. Checkered or finely netted effect produced by even the smallest veins remaining green. Poor bloom, in size and color.

Deficient manganese (Mn)

2. Leaves light green, veins lighter than adjoining interveinal areas. Some necrotic spots. Little or no drying of older leaves.

Deficient sulfur (S)

B. Terminal Bud usually dead.

1. Tips and margins of young leaves are dead. Young leaf often hooked at tip. Death of roots actually preceding all the above symptoms.

Deficient calcium (Ca)

2. Breakdown at base of young leaves. Stems and petioles brittle. Death of roots, particularly the merisematic tips.

Deficient boron (B)

Handout 3

pH PREFERENCE OF FLOWERS, HOUSE PLANTS, ORNAMENTALS, AND LAWN GRASSES

Acacia	6.0-8.0
Aechema	5.0-5.5
African Daisy	6.0-7.5
African Violet	5.5-7.5
Ageratum, Blue	6.0-7.5
Aglaonema	5.0-6.0
Alyssum	6.0-7.5
Amaryllis	5.5-6.5
Anemone	5.0-6.5
Anthurium	5.0-6.0
Arbor Vitae	6.0-7.5
Aster	6.5-7.0
Azalea	4.5-6.0
Baby's Breath (Gypsophila)	6.0-7.5
Baby's Tears	5.0-5.5
Bachelor Button	6.0-7.5
Begonia	5.5-7.0
Bird of Paradise	6.0-6.5
Bleeding Heart	6.0-7.5
Bloodleaf	5.5-6.5
Blue Bell	6.0-7.5
Bougainvillea	5.5-7.5
Boxwood	6.0-7.5
Bridal Wreath	6.0-8.0
Burning Bush	5.5-7.5
Cacti	4.5-6.0
Cactus, Christmas	5.0-6.5
Calendula	5.5-7.0
Camellia	4.5-5.5
Campanula	5.5-6.5
Candytuft	5.5-7.0
Canna	6.0-8.0
Carnation	6.0-7.5
Chrysanthemum	6.0-7.5
Cineraria	5.5-7.0
Clarkia	6.0-6.5
Clematis	5.5-7.0
Coleus	6.0-7.0
Columbine	5.5-7.0
Columnea	4.5-5.5
Coral Bells	6.0-7.0
Cosmos	5.0-8.0
Crab, Flowering	5.0-6.5
Crassula	5.0-6.0
Creeping Fig	5.0-6.0
Crocus	6.0-8.0
Croton	5.0-6.0
Crown-of-thorns	6.0-7.5
Cyclamen	6.0-7.0
Daffodil	6.0-6.5
Dahlia	6.0-7.5
Daisy, Ox-eye (wild)	6.0-7.5
Daisy, Shasta	5.0-6.0
Daphne	6.5-7.5
Delphinium	6.0-7.5
Deutzia	6.0-7.5
Dieffenbachia	5.0-6.0
Dogwood	5.0-6.0
Dracaena	5.0-6.0
Episcia	6.0-7.0
Ecualyptus	6.0-8.0
Euphorbia	6.0-7.0
Ferns: Asparagus	6.0-8.0
Bird's Nest	5.0-5.5
Boston	5.5-6.5
Maidenhair	6.0-8.0
Feverfew	6.5-7.0
Fir: Balsam	5.0-6.0
Douglas	6.0-7.0
Fittonia	5.5-6.5
Forget-me-not	6.0-8.0
Forsythia	6.0-8.0
Foxglove	6.0-7.5
Fressia	6.0-7.5
Fuchsia	5.5-6.5
Gardenia	5.0-6.0
Geranium	6.0-8.0
Gerbera	6.0-7.0
Gladiolus	6.0-7.0
Gloxinia	5.5-6.5
Godetia	6.0-7.5
Grass: Bent	5.5-6.5
Bermuda	5.0-7.0
Blue,Kentucky	6.0-7.5
Clover	5.5-7.0
Fescue	5.5-7.5
Red Top	5.0-7.5
Ryegrass	5.5-8.0
St. Augustine	6.0-8.0
Wheatgrass	6.0-8.5
Zoysia	4.5-7.5
Grevillea	5.5-6.5
Hawthorne	6.0-7.0
Heather	4.5-6.0
Heliotrope	6.0-8.0
Hemlock	5.0-6.0
Hens and Chickens	6.0-8.0
Hibiscus, Chinese	6.0-8.0
Holly, English	4.0-5.5
American	5.0-6.0
Hollyhock	6.0-8.0
Honeysuckle Bush	6.5-8.0
Hoya	5.0-6.5
Hyacinth	6.5-7.5
Hydrangea, Blue	4.0-5.0
Pink	6.0-7.0
White	6.0-8.0
Impatiens	5.5-6.5
Iris	5.5-7.5
Ivy: Boston	6.0-8.0
English	6.0-8.0
Grape	5.0-6.5
Jack-in-Pulpit	6.0-8.0
Jacob's Ladder	5.0-7.5
Jasmine	5.5-7.0
Lady's Slipper	5.0-6.0
Larkspur	6.0-7.5
Laurel	4.5-6.0
Lemon Plant	6.0-7.5
Lilac	6.0-7.5
Lily: Calla	6.0-7.0
Day	6.0-8.0
Easter	6.0-7.0
Tiger	6.0-7.0
-of-the-Valley	4.5-6.0
Lupine	5.0-6.0
Magnolia, Sweet Bay	4.0-5.0
Maple, Japanese	6.0-8.0
Maranta	5.0-6.0
Marigold	5.5-7.0
Mock Orange	6.0-8.0
Monstera	5.0-6.0
Morning Glory	6.0-7.5
Myrtle	6.0-8.0
Narcissus	6.0-7.0
Nasturtium	5.5-7.5
Nephthytis	4.5-5.5
Oleander	6.0-7.5
Orchid	4.5-5.5
Oxalis	6.0-8.0
Palm, Cocos	6.0-7.5
Pansy	5.5-6.5
Passion Vine	6.0-7.0
Peony	6.0-7.5
Peperomia	5.0-6.0
Petunia	6.0-7.5
Philodendron	5.0-6.0
Phlox	5.0-6.0
Pick-a-Back Plant (Tolomia)	5.0-6.0
Pine, White	4.5-6.0
Pink	6.0-8.0
Poinsettia	6.0-7.5
Poppy	6.0-7.5
Portulaca	5.5-7.5
Pothos	5.0-6.0
Primrose	5.5-6.5
Pyrethrum	6.0-7.5
Quince, Japanese Flowering	6.0-7.0
Rhododendron	4.5-6.0
Rose	6.0-7.0
Rose of Sharon (Althea)	6.0-7.5
Rubber Plant	5.0-6.0
St. Paulia	6.0-7.0
Salvia	6.0-7.5
Sansevieria	4.5-7.0
Scabiosa	5.0-7.5
Scilla	6.0-8.0
Shrimp Plant	5.5-6.5
Snapdragon	6.0-7.5
Snowdrop	6.0-8.0
Spirea	6.0-7.5
Spruce, Colorado	6.0-7.0
Star of Bethlehem	6.0-8.0
Stock	6.0-7.5
Sunflower	6.0-7.5
Sweet Pea	6.0-7.5
Sweet William	6.0-7.5
Tradescantia	5.0-6.0
Tuberose	6.0-7.0
Tulip	6.0-7.0
Verbena	6.0-8.0
Violet, Common	5.0-7.5
Dogtooth	5.0-6.0
Water Lily	5.5-6.5
Wisteria	6.0-8.0
Woodbine	6.0-7.0
Yew, Japanese	6.0-7.0
Yucca	6.0-8.0
Zebrina	5.0-6.0
Zinnia	5.5-7.5

RECOMMENDED REFERENCES

There are a number of inexpensive teaching aids available on soil nutrition, soil testing, and fertilizers. This listing gives the names of those available locally which complement this teaching packet.

Catalogued items from the Instructional Materials Service, Department of Education, 3 Stone Hall, Cornell University, Ithaca, NY 14853

* *Collecting and Preparing Soil Samples for Testing*

The 4-page pamphlet outlines what equipment is needed, the number of samples to take, how to take representative samples, and how to prepare sample for testing. F 206. 15¢

* *Cornell pH Soil Test Kit*

A complete kit for testing pH levels from 5.0 to 7.2. F 201. $5.00

* *Fertilizing and Watering Shade and Ornamental Trees*

The 12-page pamphlet explains why trees should be fertilized, what elements are needed by the plant, and the use and deficiency symptoms of nitrogen, phosphorus, and potassium. When to fertilize, which fertilizer to use, and how to apply it are also explained. H 203. 25¢

* *Greenhouse Soils*

This 36-page booklet from LaMotte Chemical Products Company includes sections on the importance of soil acidity, how to control soil pH, the roles of nutrients in plant growth, a chart on general application rates of some greenhouse fertilizers, fertilization methods, and sampling and testing greenhouse soils. H 108. 50¢

* *Hunger Signs in Crops*

The 12-page pamphlet introduces the student to the sixteen essential elements for plant growth. Common deficiency symptoms are discussed and shown in six color plates. How to make tissue tests for nitrogen, phosphorus, and potassium, and how to plan a fertilizer program are also explained. F 302. 45¢

* *Lawn Care and Management*

Includes six slides on the importance of fertilizing properly. When, how much, and why to fertilize are explained. 46 slides in total. H 402S. $11.00

* *Make Production Progress with Proportioner Fertilization*

The 72 slides depict the effects of fertilizer on crop production, specific elemental deficiency symptoms in ornamental crops, procedure for taking soil samples of bench crops and potted crops for testing, types of fertilizer proportioners and their use, and seven tables from the Fertilizer Proportioner Manual to teach fertilizer materials and arithmetic. H 105S $16.00

* *Planning a Fertilizer Program*

Tables show the predicted increase in field crop yields for varying applications of limestone, phosphorus fertilizer, and potassium fertilizer. In addition, the 8-page pamphlet explains how to figure the cost of fertilizer applications and the significance of soil pH. F 208. 20¢

* *Soil Testing and Fertility*

The set of 57 transparencies with illustrated script explains how to take good representative soil samples for testing, how to plan a fertilizer program, why soils become acid or alkaline, the importance of soil pH, lime recommendations for grains and legumes, and when and how to apply phosphorus and potassium. F201TR. $8.20

* *Cornell Field Crops Handbook*

A companion publication to Cornell Recommends for Field Crops. Contains much of the general, unchanging information about producing specific field crops, including lime and fertilizer use. $3.00

* *Cornell Recommendations for: Field Crops, Vegetable Production, Potato Production, Commercial Tree-Fruit Production, or Commercial Floriculture Crops*

Published annually, these bulletins provide information on fertilizer, lime, and pesticide application. Cost per publication is usually $1.00 to $1.50.

* *Effective and Efficient Use of Nitrogen for Vegetable Production on Organic Soils*

The 6-page information bulletin gives general guidelines on how much nitrogen to use, where to apply it, how to apply it, and what form of nitrogen to apply. Fundamental principles of nitrogen use are explained. 50¢

* *Fertilizer Proportioners for Floriculture and Nursery Crop Production Management*

This 24-page information bulletin discusses selection and use of a proportioner, use of fertilizers and dyes, fertilizer application rates, fertilization systems and programs for potted crops, and soil testing. A final section includes tables for converting fertilizer weights to application rates. 24 pages. $1.00

The last two items listed above, as well as a number of bulletins that outline cultural requirements and production practices of specific crops, are available from the Mailing Room, 7 Research Park, Cornell University, Ithaca, NY 14850. Refer to the Know-How Catalog of extension publications.

Two textbooks recently published for the high school vo-ag. student are the following:

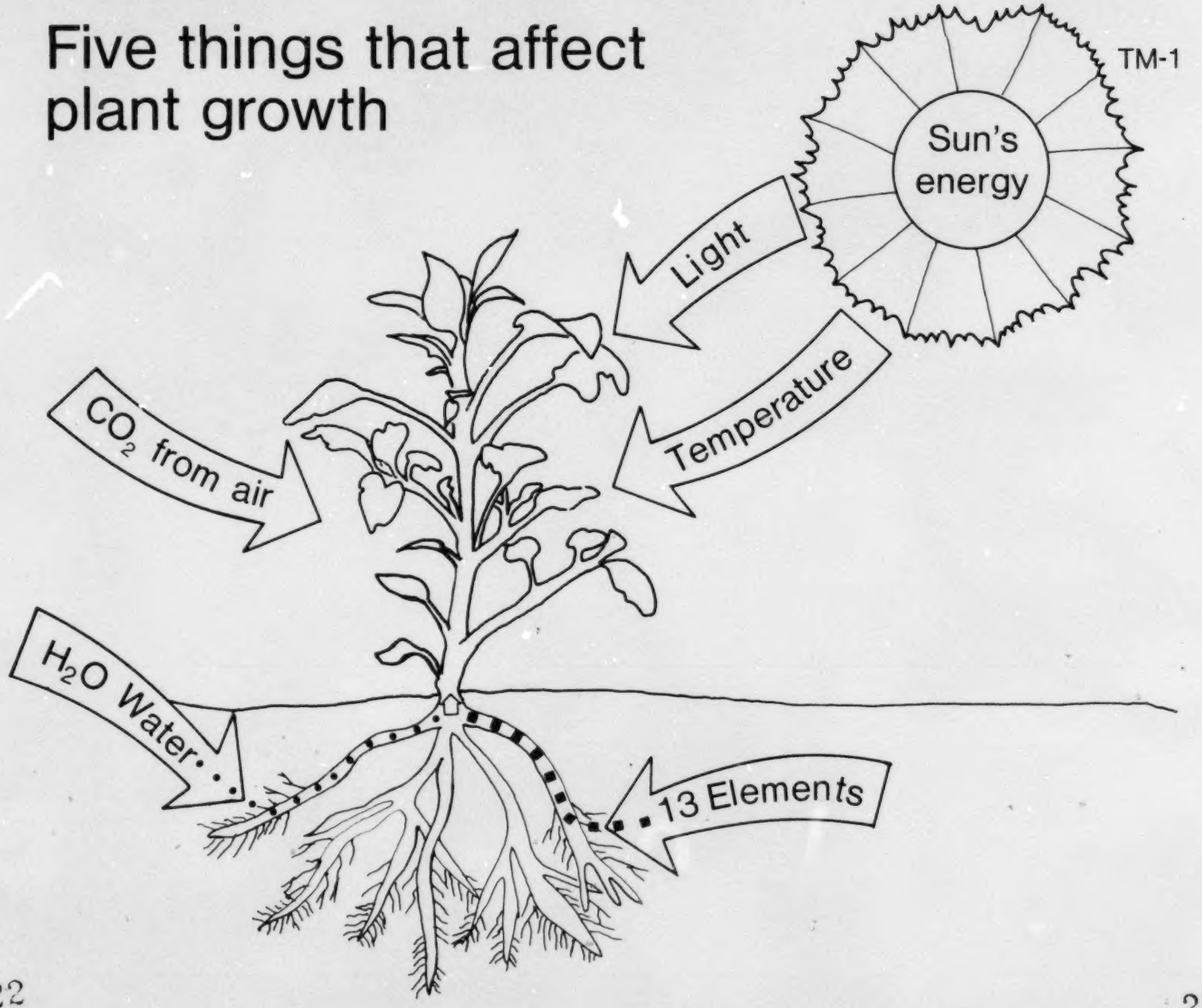
* *Using Commercial Fertilizers* Fourth edition. Malcolm H. McVickar and William M. Walker. 1978. The Interstate Printers and Publishers, Inc. $12.50

The text discusses the fertilizer industry, what plant nutrients do, the common fertilizers, principles involved in the use of fertilizers, how to measure soil fertility, methods of applying fertilizers, fertilizer-pesticide combinations, economics of fertilizer usage, and fertilizers and the environment. Tables and photographs help illustrate concepts and facts. Each chapter ends with a list of review questions. 360 pages.

* *Soil and Soil Management* Charles D. Sopher and Jack V. Baird. 1978. Reston Publishing Company, Reston, Virginia 22090

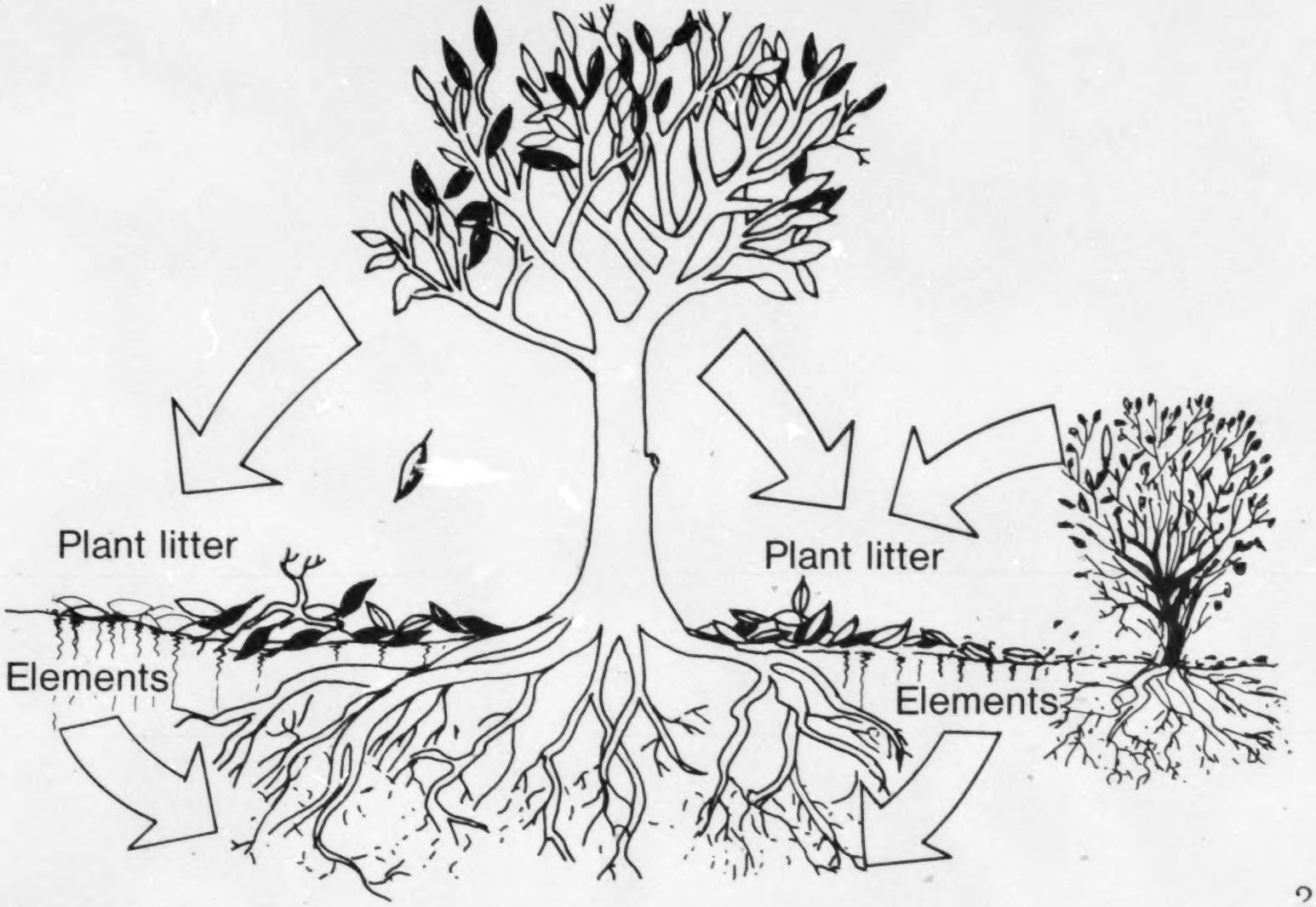
The text was developed to be used as a very general soils text for students without geological, chemical, and mathematical backgrounds. The chapters are concise. Four chapters are devoted to plant nutrition and fertilizer use. Each chapter concludes with a summary and set of review questions. 234 pages.

Five things that affect plant growth



Decaying plant material returns elements to soil

TM-2a

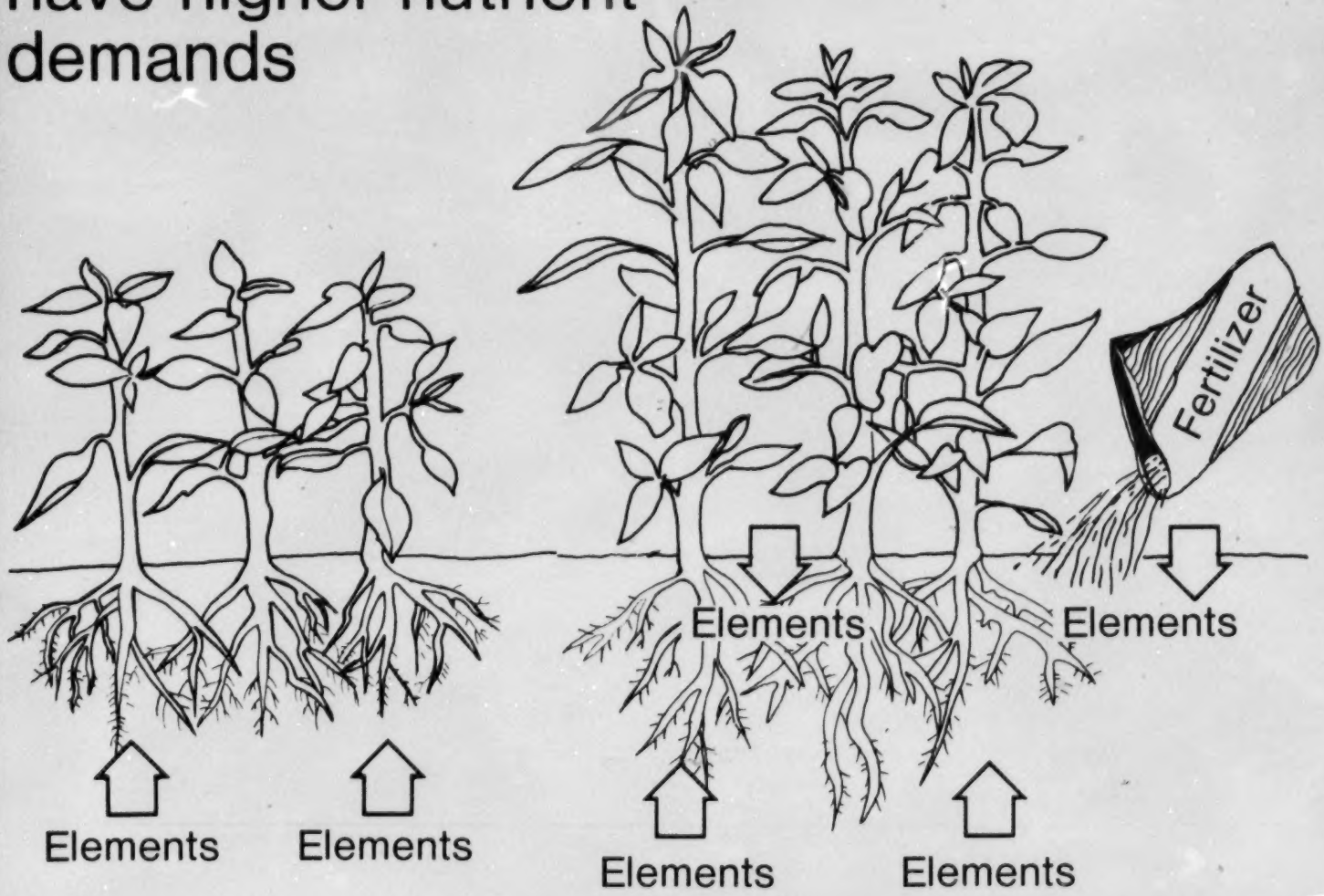


Removal of plant litter breaks the cycle

TM-2b

Higher yielding varieties have higher nutrient demands

TM-3



Soilless mixes or perlite, vermiculite, and sand provide few elements.

TM-4

To add elements, add fertilizer.

Essential elements

TM-5

From air and water:

Carbon	C
Oxygen	O
Hydrogen	H

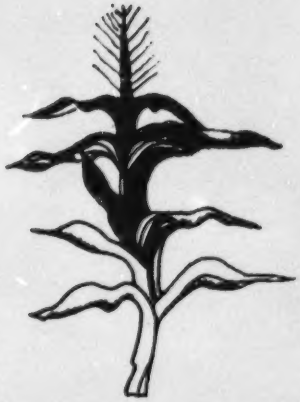
From soil:

Macronutrients		Micronutrients	
Nitrogen	N	Manganese	Mn
Phosphorus	P	Zinc	Zn
Potassium	K	Boron	B
Calcium	Ca	Copper	Cu
Sulfur	S	Iron	Fe
Magnesium	Mg	Molybdenum	Mo
		Chlorine	Cl

Deficiency symptoms

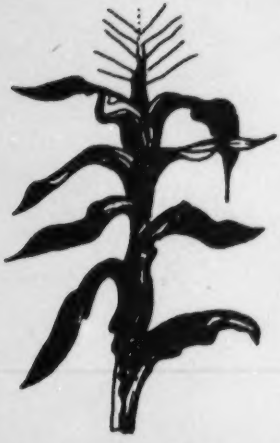
TM-6

What elements does each plant probably lack: nitrogen, phosphorus, or potassium?



Lower leaves are yellow with brown edges.

Plant is overall light green. Lower leaves are lightest in color.



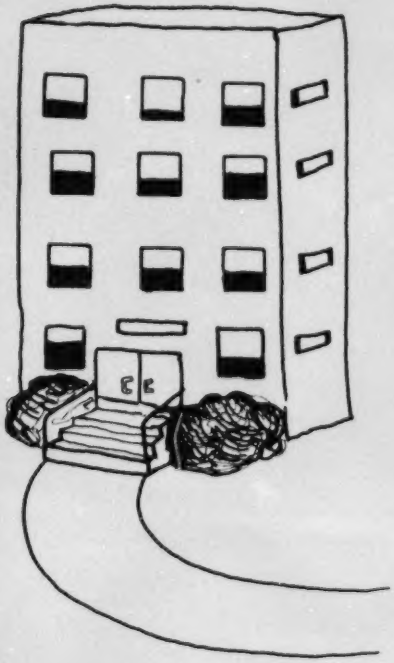
Dark green leaves. Healthy plant. N, P, K all present.

Dark green leaves with purplish edges.

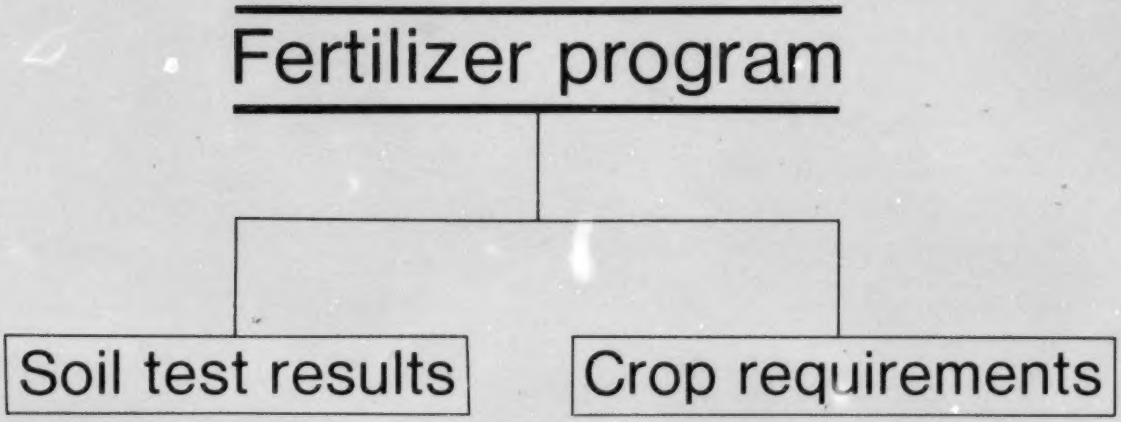
Soil testing

TM-7

1. Perform your own soil test.

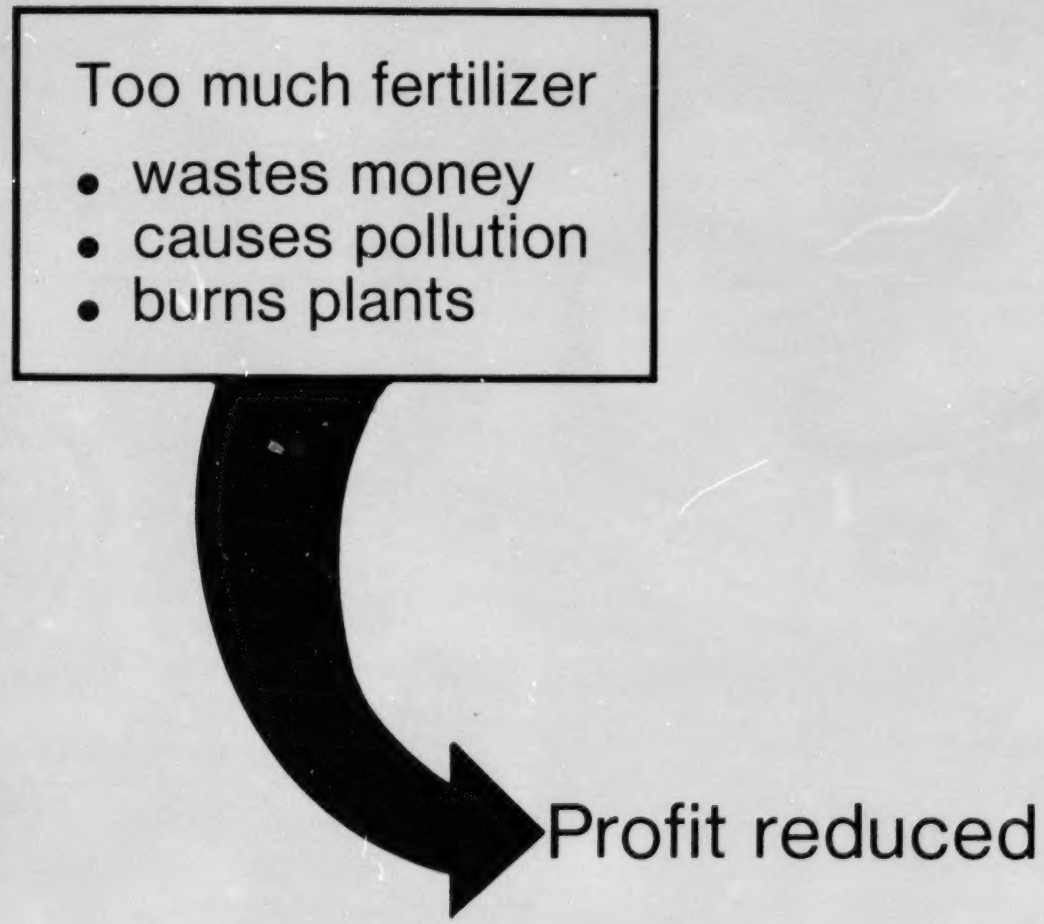


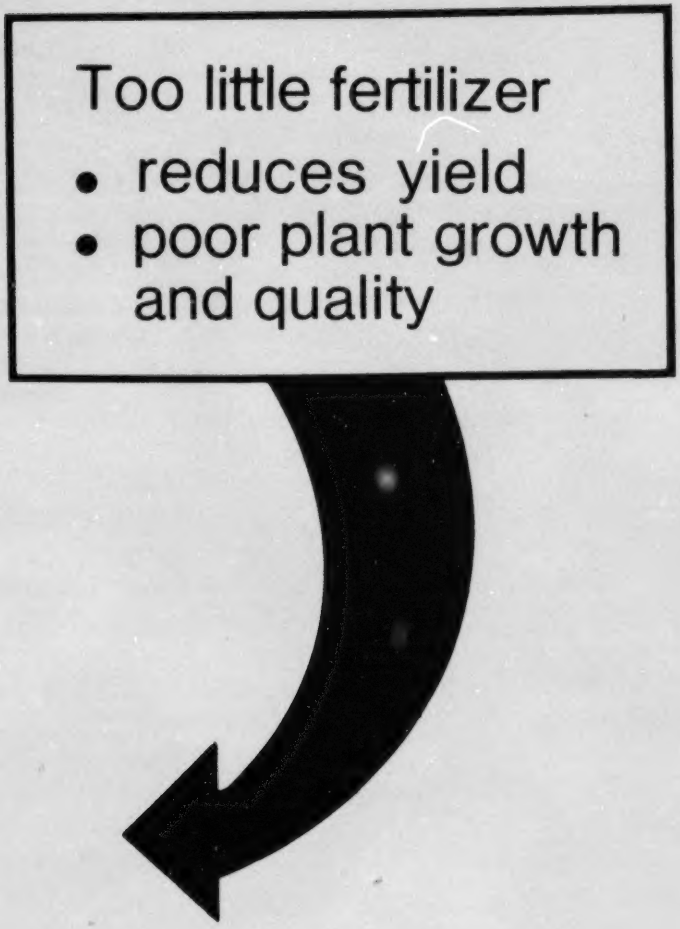
2. Send soil sample to soil-testing lab.
   - Land grant college, such as Cornell University
   - Private company
   - County cooperative extension office


Fertilizer program
Soil test results
Crop requirements

Planning a fertilizer program

TM-9a

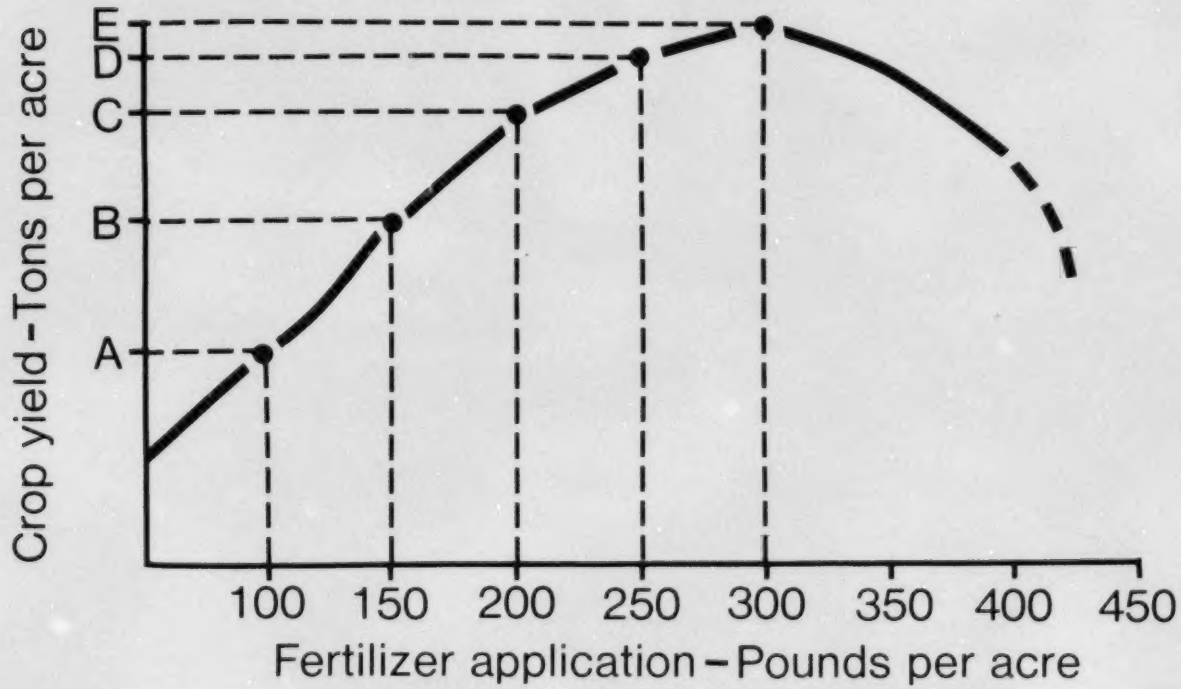



Too little fertilizer
• reduces yield
• poor plant growth and quality

Planning a fertilizer program

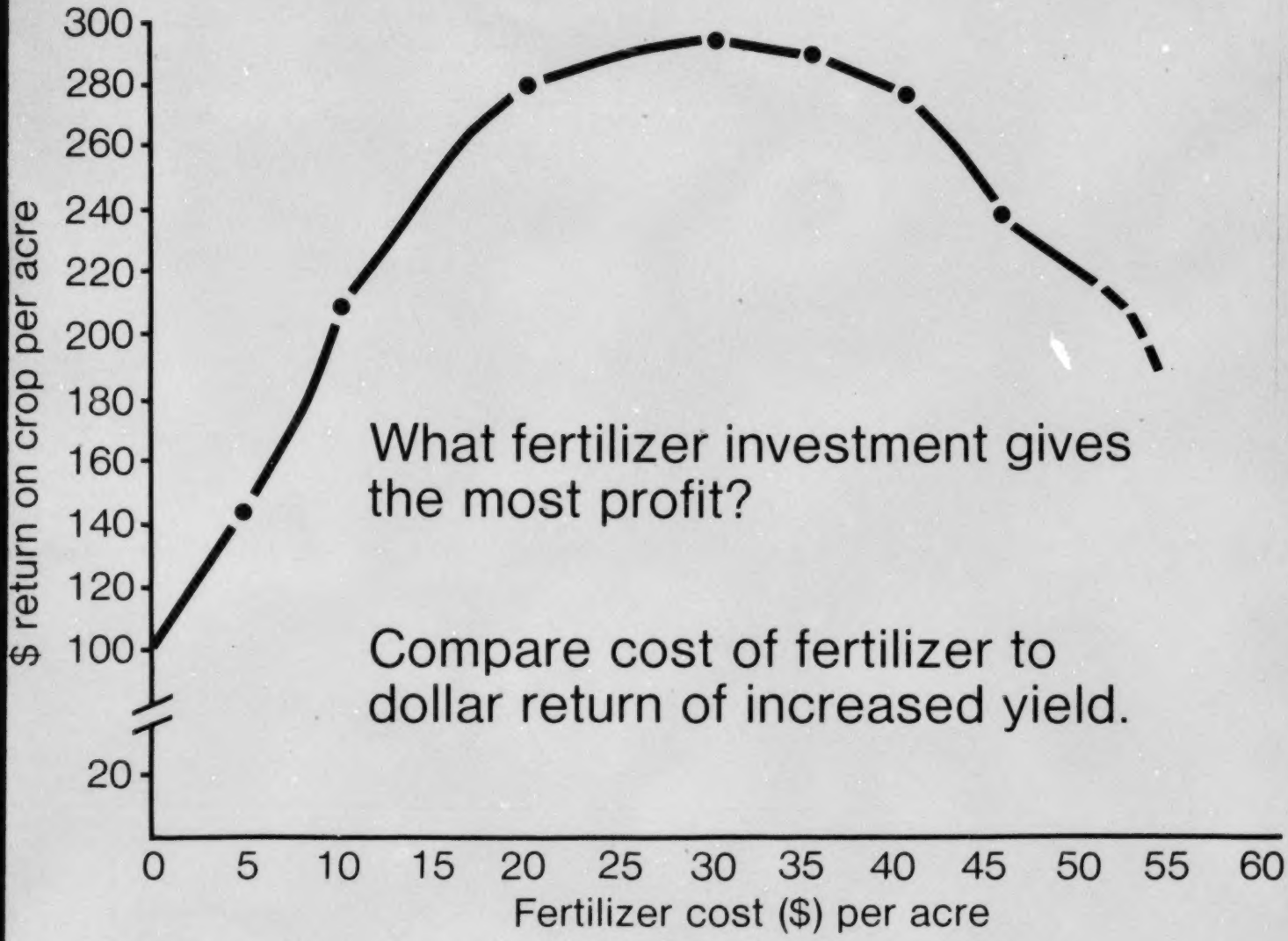
TM-10

This chart shows that a fertilizer application of 300 pounds per acre gives the highest yield (E). But, is it worth the money?



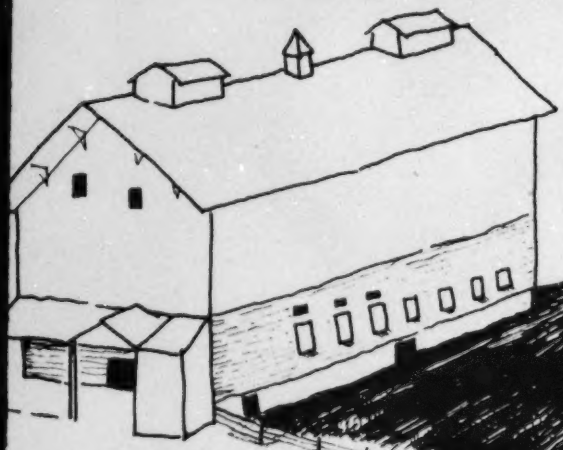
Planning a fertilizer program

TM-11



What fertilizer rate gives the most profit?

TM-12



Remember: The last fertilizer increment should give a greater dollar return than it costs.

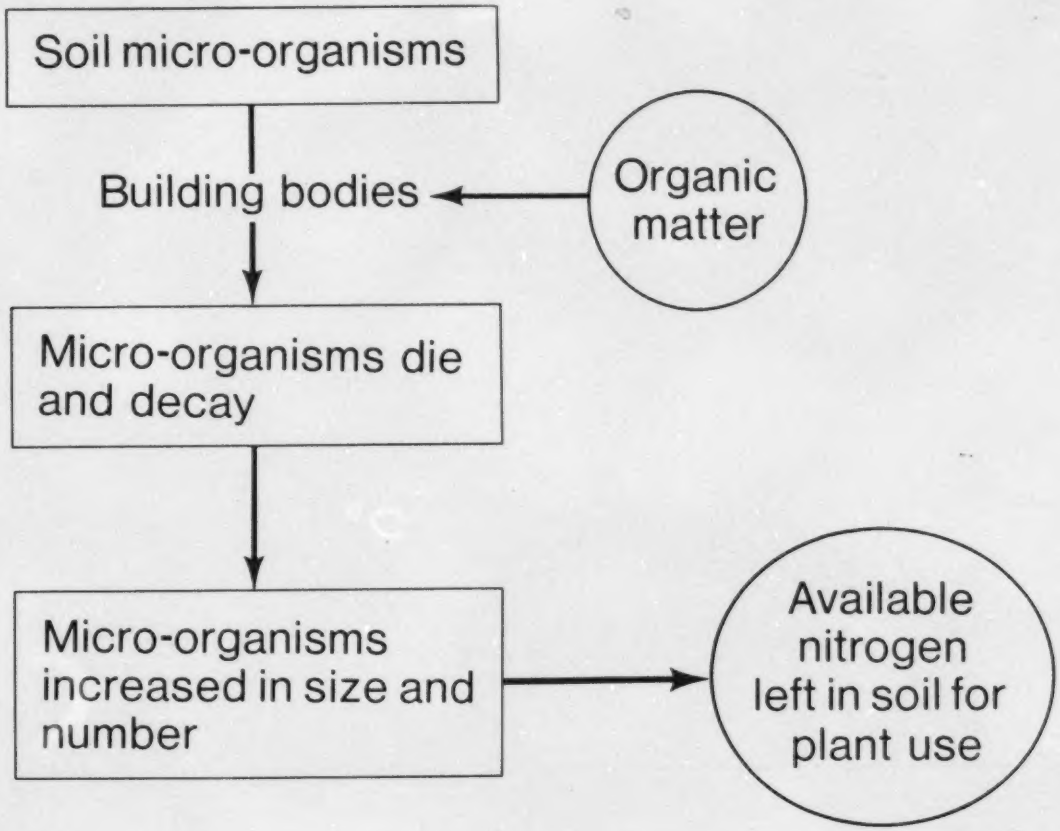
Fertilizer price	20¢/lb.
Market price, corn	$2.00/bushel

Fertilizer rate	Cost	Yield	Crop income
lbs./A	$/A	bu./A	$/A
30		100	
60		120	
90		130	
120		145	
150		150	
180		154	
210		155	

Organic fertilizers:

TM-13

Derived from animal and plant sources


Soil micro-organisms
Building bodies
Organic matter
Micro-organisms die and decay
Micro-organisms increased in size and number
Available nitrogen left in soil for plant use

Nutrient content of fresh manure

TM-14

TYPE	TONS OF MANURE PER YEAR PER 1000 LB. OF ANIMAL	POUNDS PER TON OF MANURE		
		N	P_2O_s	K_2
Cattle	15	10	5	8
Poultry	5	30	20	12
Swine	13	12	9	11
Horse	8	14	5	14

Source: *Cornell Field Crops Handbook*

Amount of nutrients available for plant use for one year

TM-15

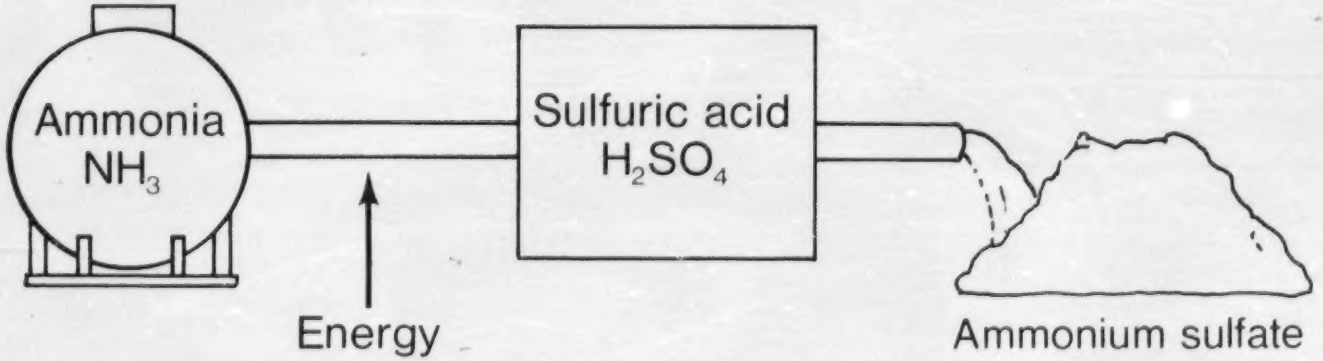
Type of Manure	Nutrient	Fall or Winter Application	Spring Application, Immediately Plowed
		Pounds per ton of manure	
Cattle	N	5	7
	P_2O_5	3	3
	K_2O	6	6
Swine	N	6	8
	P_2O_5	6	6
	K_2O	6	6
Poultry			
Fresh, sticky	N	10	15
	P_2O_5	12	12
	K_2O	10	10
Moist to crumbly	N	20	20+
	P_2O_5	25	25
	K_2O	20	20
Crumbly to dry	N	30	30+
	P_2O_5	35	35
	K_2O	30	30

Note: Nutrient loss occurs during winter and early spring. For nutrient conservation, apply and incorporate manure after mid-April.

Source: *Cornell Field Crops Handbook.*

Inorganic fertilizers: Usually manufactured; commercial fertilizers

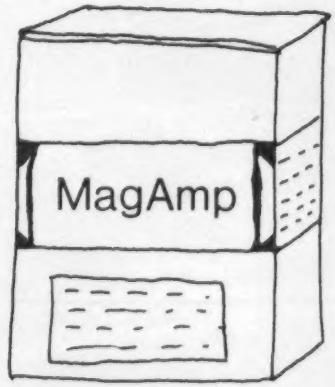
For example: manufacturing a nitorgen fertilizer



Slow-release fertilizers:

TM-17

Granules are treated so a small amount of fertilizer is released over a long period of time

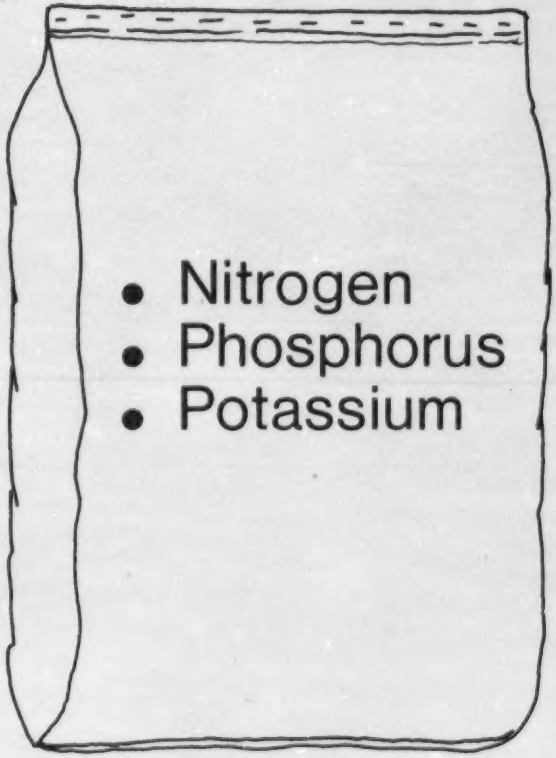


Two common brands

Complete fertilizer:

TM-18

Contains all three primary macronutrients, N-P-K



Nitrogen (N):

TM-19

- Most important element of fertilizers
- Moves quickly through soil

INORGANIC SOURCES
Ammonium nitrate, 33%N
Anhydrous ammonia, 82%N
Ammonium sulfate, 21%N

ORGANIC SOURCES
Urea, 42%N
Fish meal, 10%N
Manure, 1-4%N

Phosphorus (P):

TM-20

- Not very mobile in soil
- Apply to root zone before planting
- Available to plants as phosphate, P_2O_5

SOURCES
Single superphosphate, 18-20% P_2O_5
Triple superphosphate, 43-48% P_2O_5
Bone meal, 23% P_2O_5
Ammonium phosphate, 20% P_2O_5
Monoammonium phosphate, 45-48% P_2O_5
Diammonium phosphate, 42-46% P_2O_5

Potassium (K):

TM-21

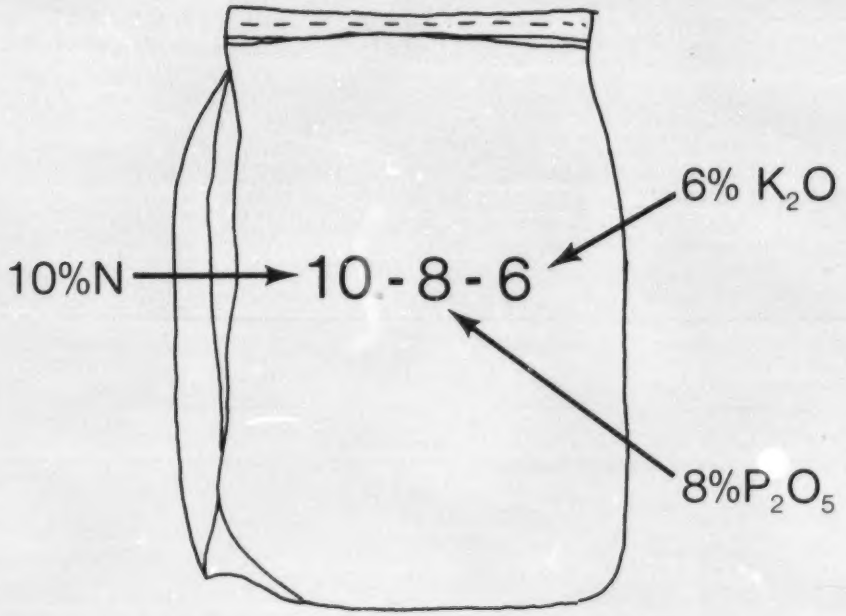
- Slightly mobile in the soil
- Available as potash, K_2O

SOURCES
Potassium sulfate, 52% K_2O
Potassium chloride, 60% K_2O
Potassium nitrate, 38% K_2O

Reading the fertilizer label

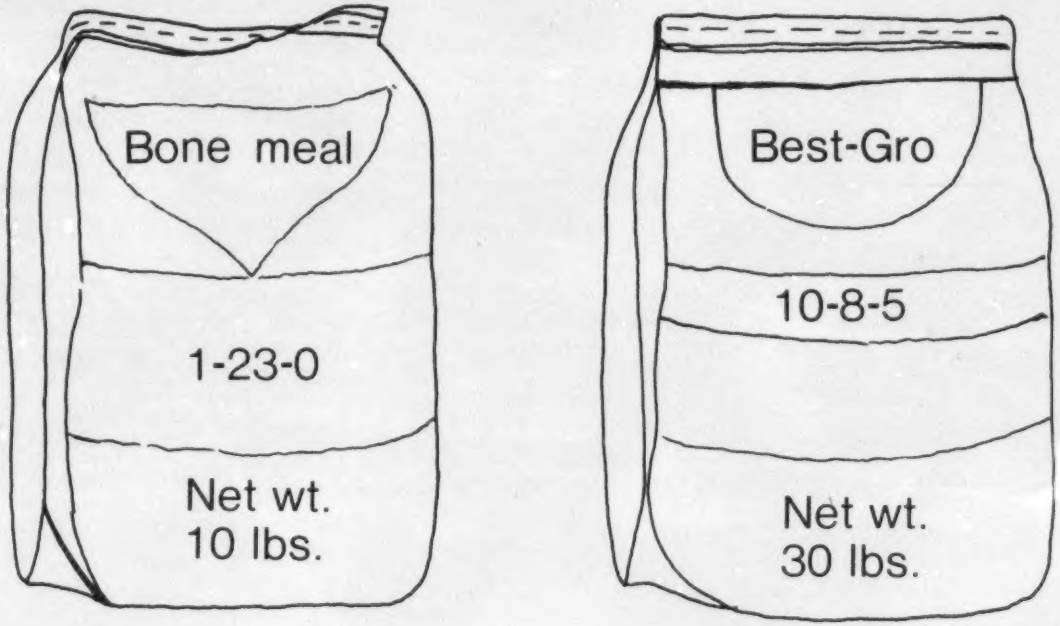
TM-22

Three large numbers on every fertilizer label tell the percentage by weight of $N - P_2O_5 - K_2O$



Which bag of fertilizer has more phosphorus in it?

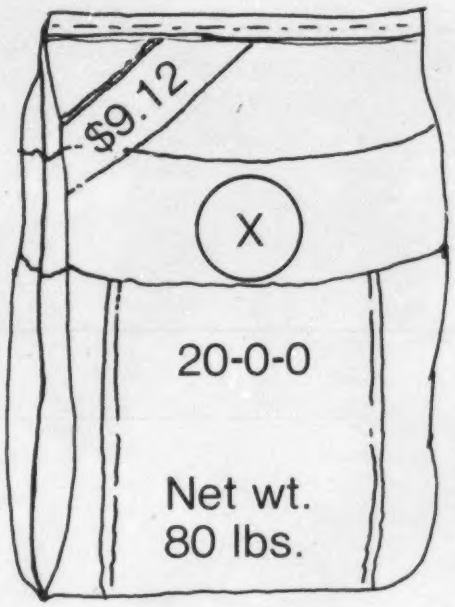
TM-23

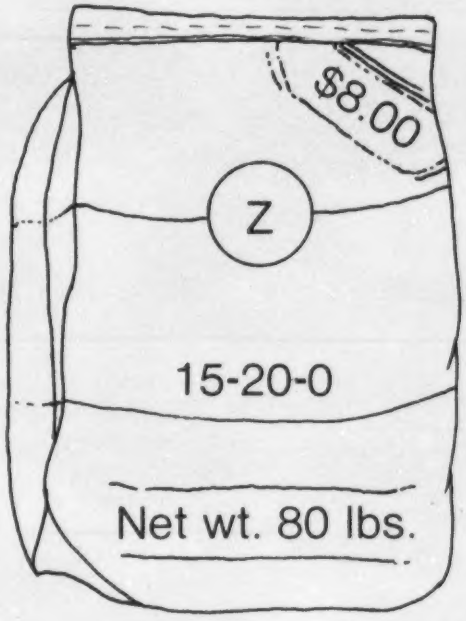


% P x lbs. of fertilizer= lbs. of P

Your plants need an application of NITROGEN (N). Which brand of fertilizer is the best deal?

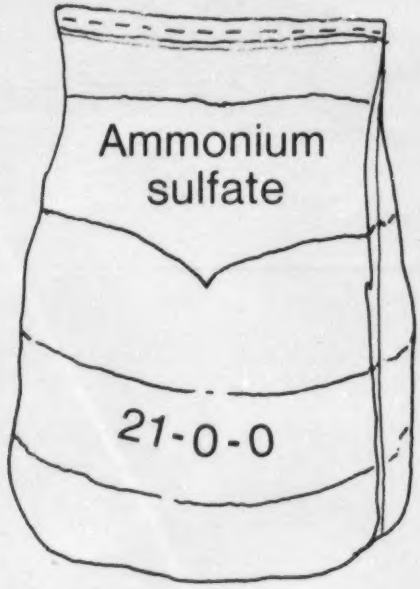
TM-24





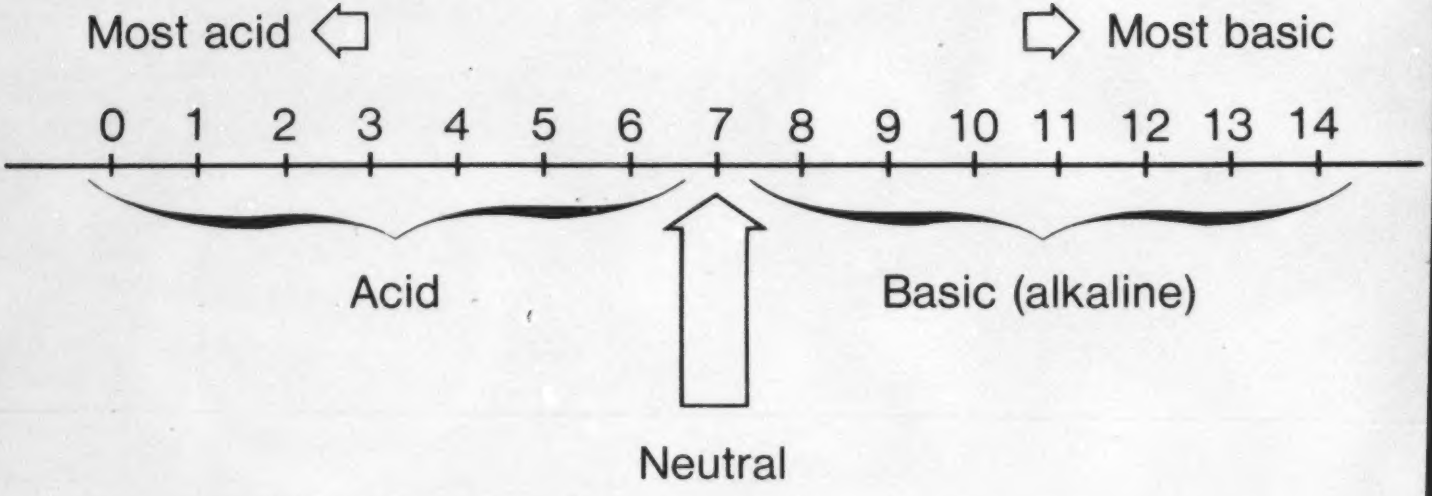
TM-25

You need to apply 63 pounds of nitrogen per acre. How much ammonium sulfate must be applied per acre?



pH scale

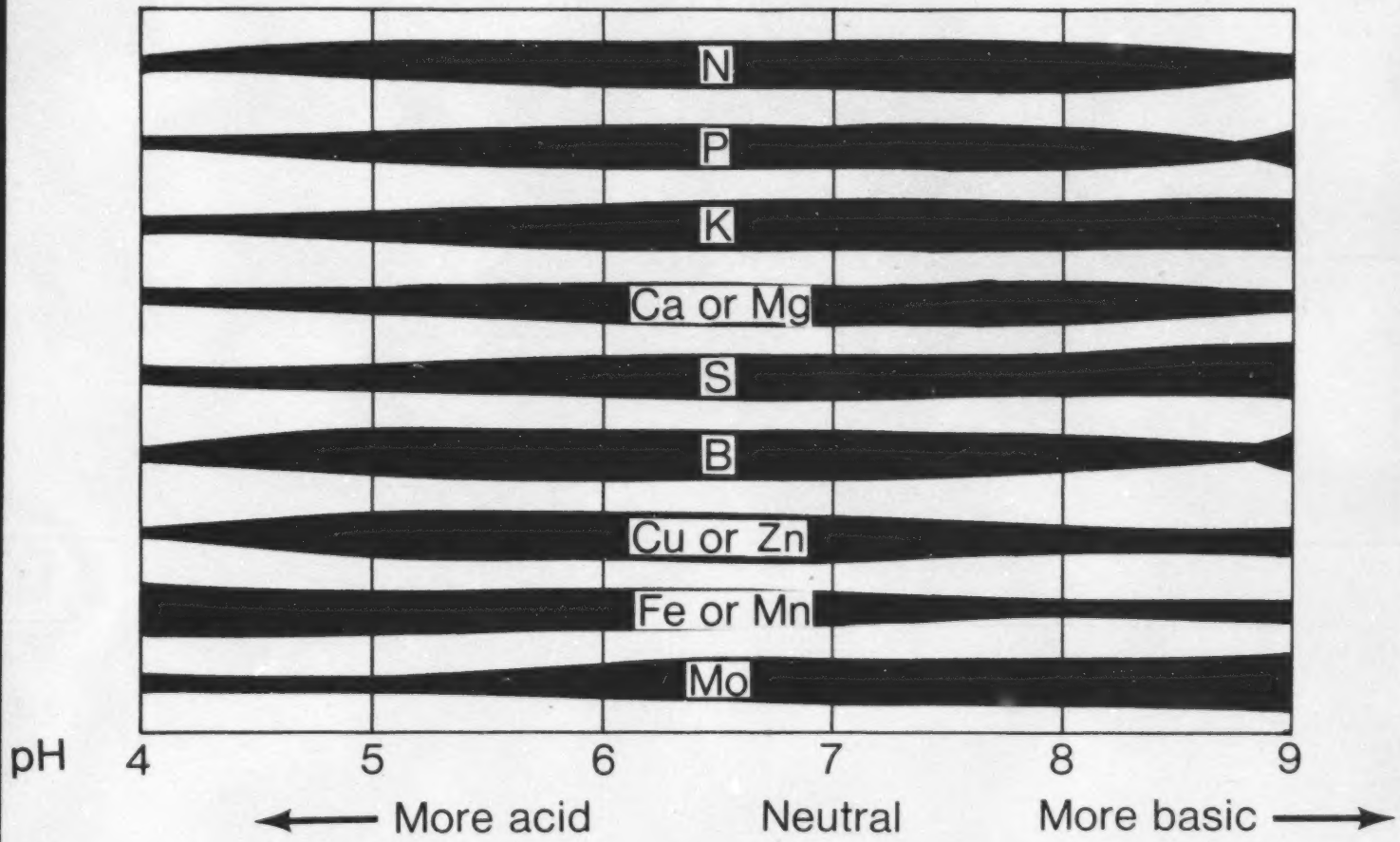
TM-26



Availability of elements:

TM-27

The wider the bar, the more available the element.



Recommended soil pH for some field crops

TM-28

Alfalfa	6.6 to 7.0
Barley	6.3 to 6.5
Birdsfoot trefoil	6.3 to 6.5
Clovers	5.8 to 6.2
Corn	5.8 to 6.2
Grasses	5.8 to 6.2
Oats	5.8 to 6.2
Soybeans	6.6 to 7.0
Wheat	6.3 to 6.5

Source: *Cornell Field Crops Handbook*

Recommended soil pH for some fruit and nut crops

TM-29

Apples	5.0 - 6.5	Lemons	6.0 - 7.0
Blackberries	5.0 - 6.0	Olives	5.5 - 6.5
Cherry (sweet)	6.0 - 7.5	Oranges	6.0 - 7.5
(sour)	6.0 - 7.0	Peaches	6.0 - 7.5
Crabapples	6.0 - 7.5	Pears	6.0 - 7.5
Cranberries	4.2 - 5.0	Pecans	6.4 - 8.0
Currants, red	5.5 - 7.0	Pineapple	5.0 - 6.0
Gooseberries	5.0 - 6.5	Plums	6.0 - 8.0
Grapes	5.5 - 7.0	Quince	6.0 - 7.5
Grapefruit	6.0 - 7.5	Raspberries,	
Hazel nuts	6.0 - 7.0	black	5.0 - 6.5
Hickory nuts	6.0 - 7.0	red	5.5 - 7.0
Kumquats	5.5 - 6.5	Walnuts	6.0 - 8.0

Recommended soil pH for some vegetable and fruit crops

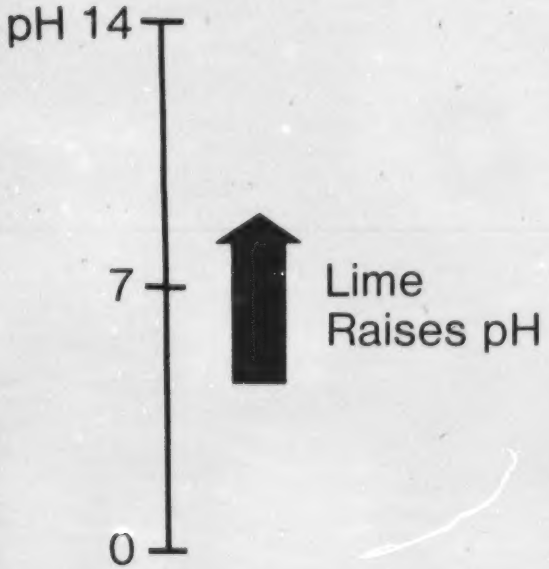
TM-30

Asparagus	6.0 - 8.0	Onions	6.0 - 7.0
Beans, lima	6.0 - 7.0	Peas	6.0 - 7.5
pole	6.0 - 7.5	Peppers	5.5 - 7.0
Broccoli	6.0 - 7.0	Pumpkin	5.5 - 7.5
Brussels sprouts	6.0 - 7.5	Radishes	6.0 - 7.0
Cabbage	6.0 - 7.5	Rhubarb	5.5 - 7.0
Cantaloupe	6.0 - 7.5	Spinach	6.0 - 7.5
Carrots	5.5 - 7.0	Squash,	
Cauliflower	5.5 - 7.5	crookneck	6.0 - 7.5
Celery	5.8 - 7.0	Strawberries	5.0 - 6.5
Cowpeas	5.0 - 6.5	Swiss chard	6.0 - 7.5
Cucumbers	5.5 - 7.0	Tomatoes	5.5 - 7.5
Eggplant	5.5 - 6.5	Turnips	5.5 - 6.8
Lettuce	6.0 - 7.0	Watermelon	5.5 - 6.5

Limestone: added to the soil to raise pH (make more basic)

TM-31

- Calcium limestone ($CaCO_3$)
- Dolomitic limestone ($CaCO_3$ and $MgCO_3$)
- Hydrated lime ($Ca(OH)_2$)



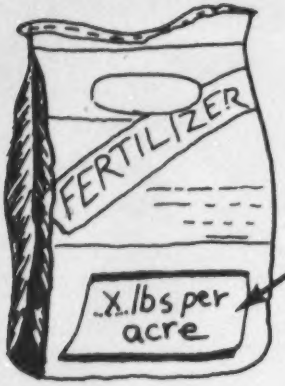
How much fertilizer to apply depends on:

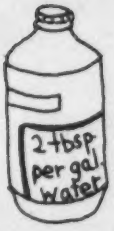
TM-32

1. Soil type
2. Weather
3. Season
4. Crop

For fertilizer application rate:

TM-33

1. 

Look at the label 

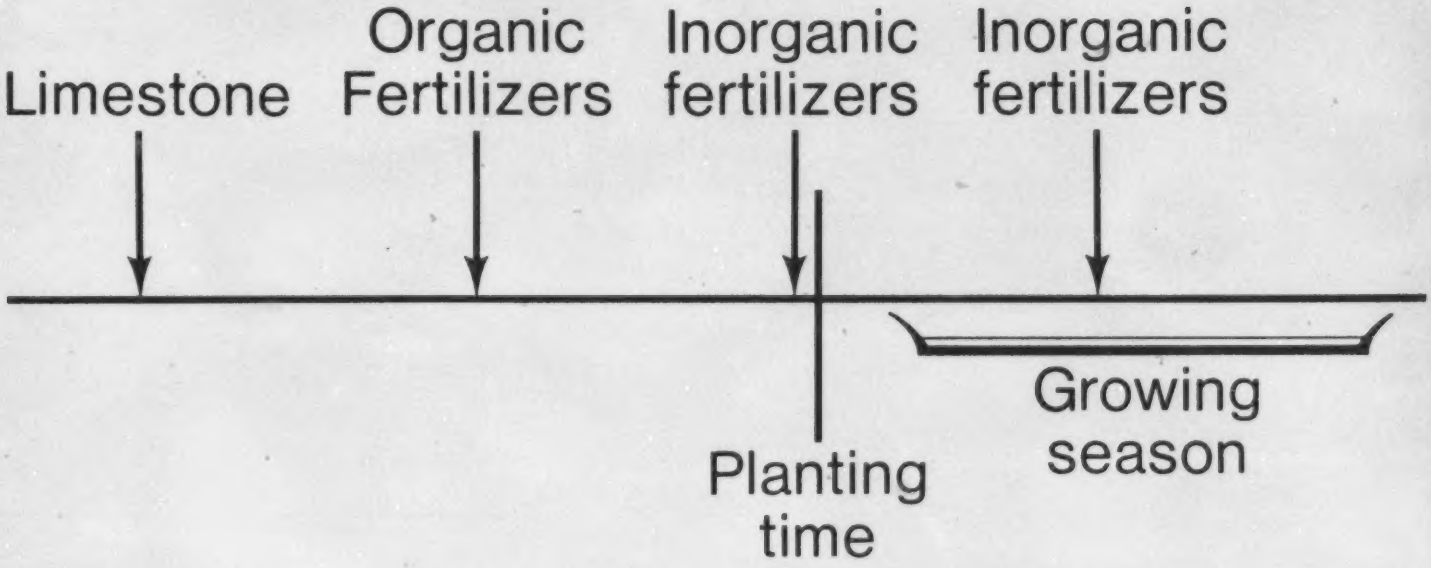
2. Call the local county co-operative extension office.

3. Refer to:

Time of application

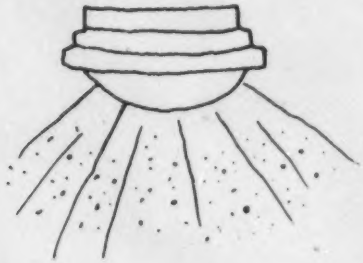
TM-34

In general . . . . .



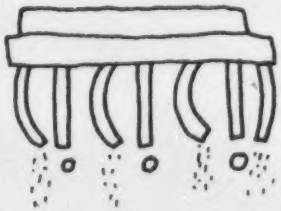
Ways to apply dry fertilizer

TM-35



Broadcast
(preplant)

Sidedress
(postplant)



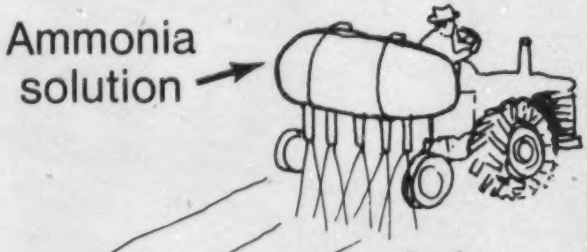
Band
(at planting)

Drill
(place in
auger
holes)

Ways to apply liquid fertilizer

TM-36

Apply in irrigation water



Inject
into soil

Spray on foliage

Inject into
trunk

Things to consider when selecting a fertilizer and application method

TM-37

1. Crop
2. Soil type and analysis
3. Elements to be applied
4. Equipment available
5. Nature and slope of soil surface
6. Season
7. Weather
8. Other plants in the area
9. Commercial agencies available on contract

SITUATION:

TM-38

You own a farm in central New York State. While attending the local county fair, you talk with two of your neighbors. What would you say in response to their statements?

Neighbor #1

"I've grown a rotation of oats and birdsfoot trefoil for twenty years. This year, I'm going to plant soybeans. I guess I'll just continue with the same fertilizer and lime program that I've been using. What do you think?

Neighbor #2

"Last year the county agent told me to increase my application of nitrogen fertilizer. I did and my yields increased. I figure if I double the application this year, I'll double my yield and my profits! You should do the same."

SITUATION:

TM-39

Your neighbor brings some leaves to you. She complains that the plant growth is stunted and the plant looks terrible. You notice that the leaves are purplish when they should be green. When questioned about cultural practices, she says that she fertilizes with ammonium sulfate (21-0-0) only. What do you suspect is wrong with her plant?

SITUATION:

You work in a garden center that sells house plants and outdoor ornamental plants. It is a busy Saturday in May. What would you tell customers who ask you the following?

Customer #1

"I just purchased a new home and want to plant three rhododendrons in the front yard. Is there anything special to consider as far as soil condition?"

Customer #2

"The spider plant I purchased last fall looks terrible. The leaves are yellow and white, instead of the nice green and white as when I purchased it. It hangs in a window that gets bright light so I must water it every few days. What's wrong with it? Maybe you should give me a refund."